FIG. 1
(PRIOR ART)

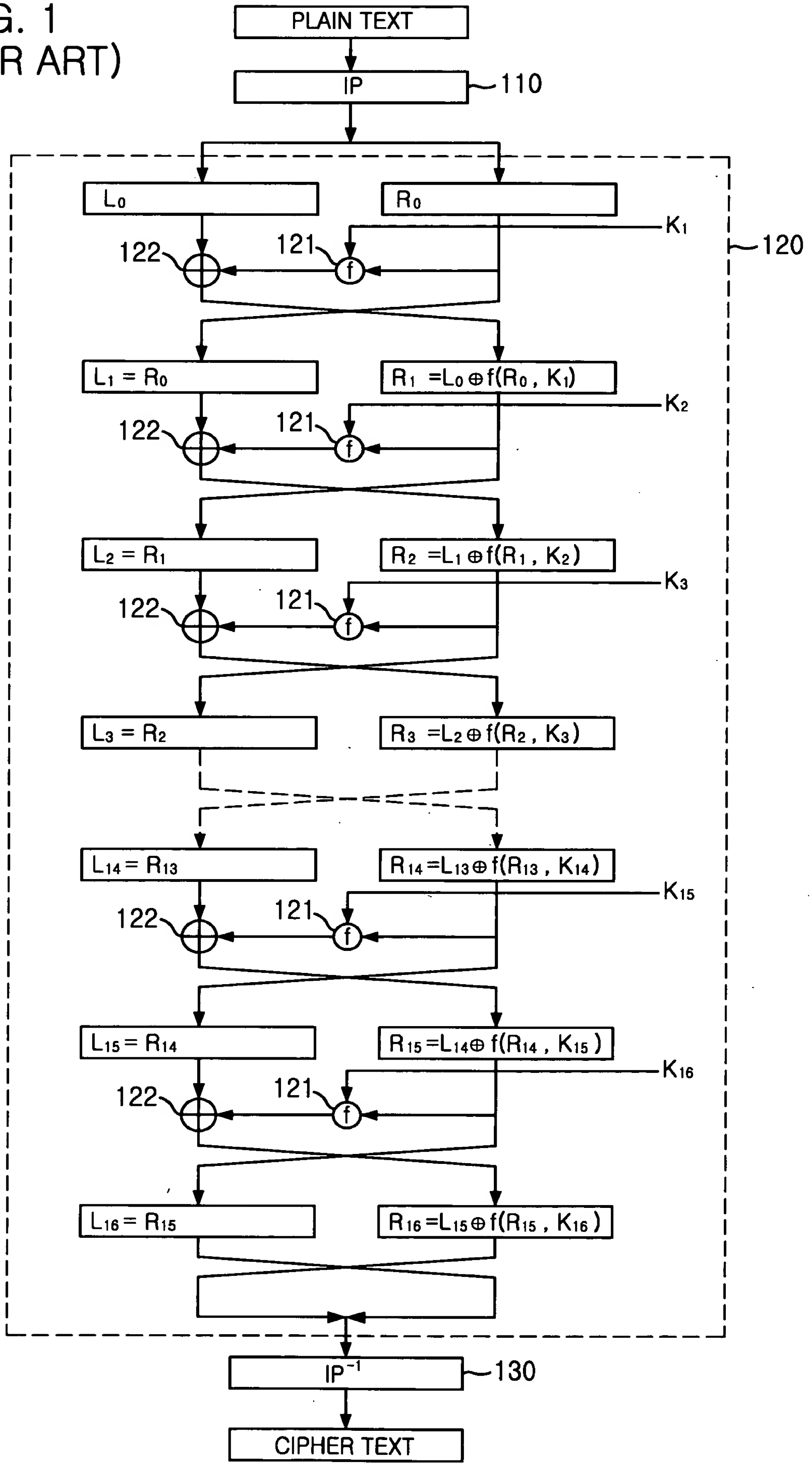

PLAIN TEXT
IP
110
L_0
R_0
K_1
120
122
121
f
$L_1 = R_0$
$R_1 = L_0 \oplus f(R_0, K_1)$
K_2
122
121
f
$L_2 = R_1$
$R_2 = L_1 \oplus f(R_1, K_2)$
K_3
122
121
f
$L_3 = R_2$
$R_3 = L_2 \oplus f(R_2, K_3)$
$L_{14} = R_{13}$
$R_{14} = L_{13} \oplus f(R_{13}, K_{14})$
K_{15}
122
121
f
$L_{15} = R_{14}$
$R_{15} = L_{14} \oplus f(R_{14}, K_{15})$
K_{16}
122
121
f
$L_{16} = R_{15}$
$R_{16} = L_{15} \oplus f(R_{15}, K_{16})$
IP^{-1}
130
CIPHER TEXT

FIG. 2
(PRIOR ART)

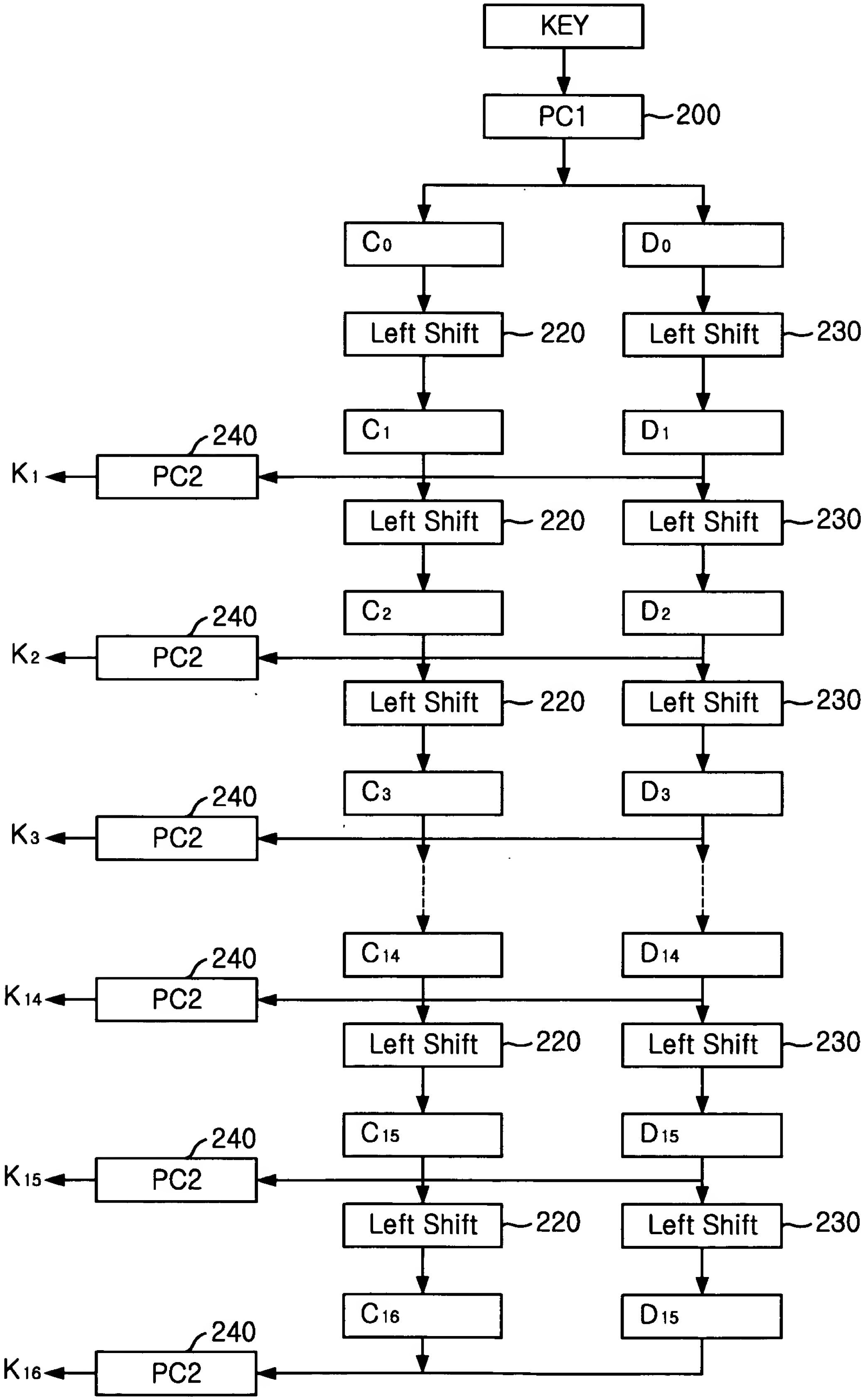


FIG. 3
(PRIOR ART)

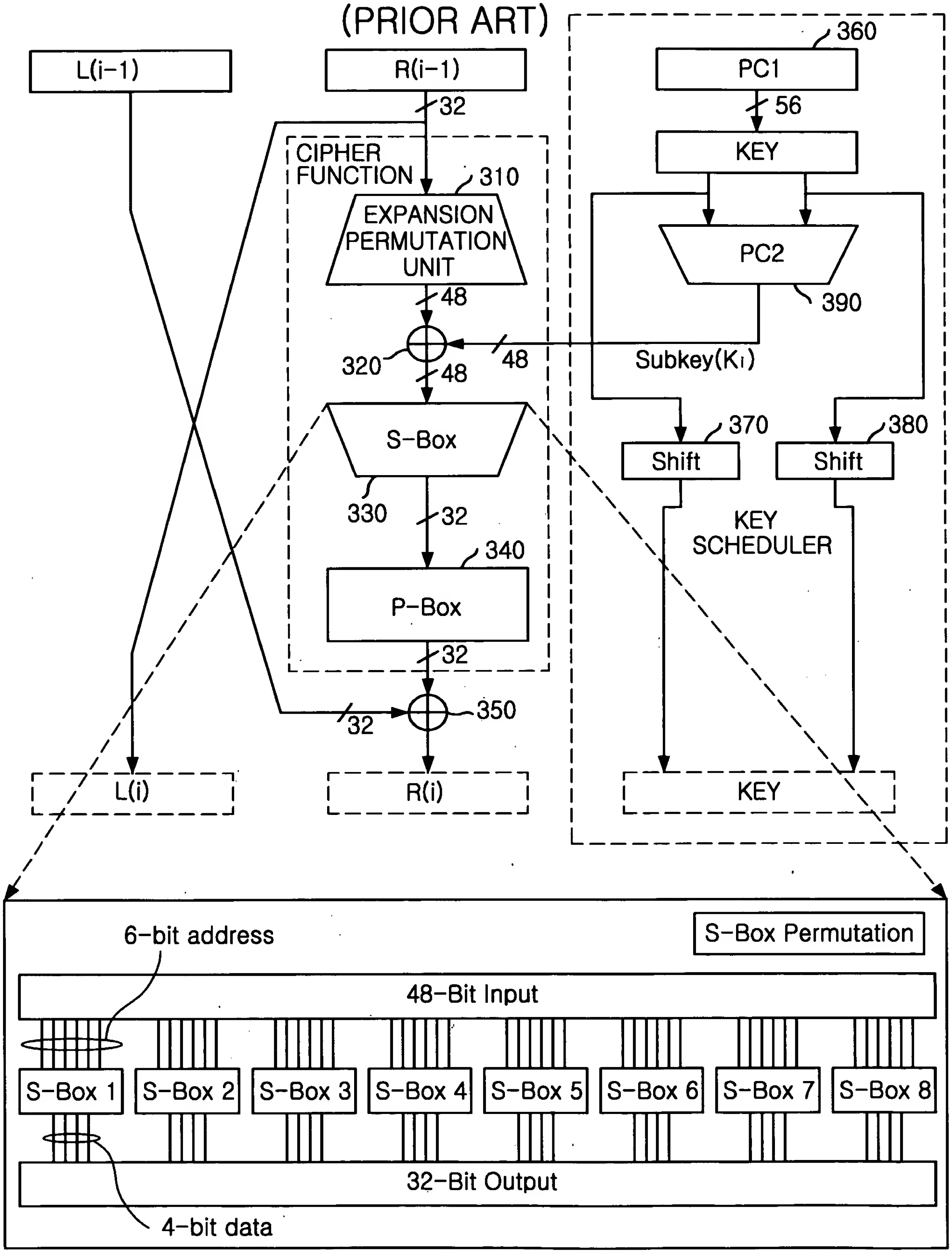
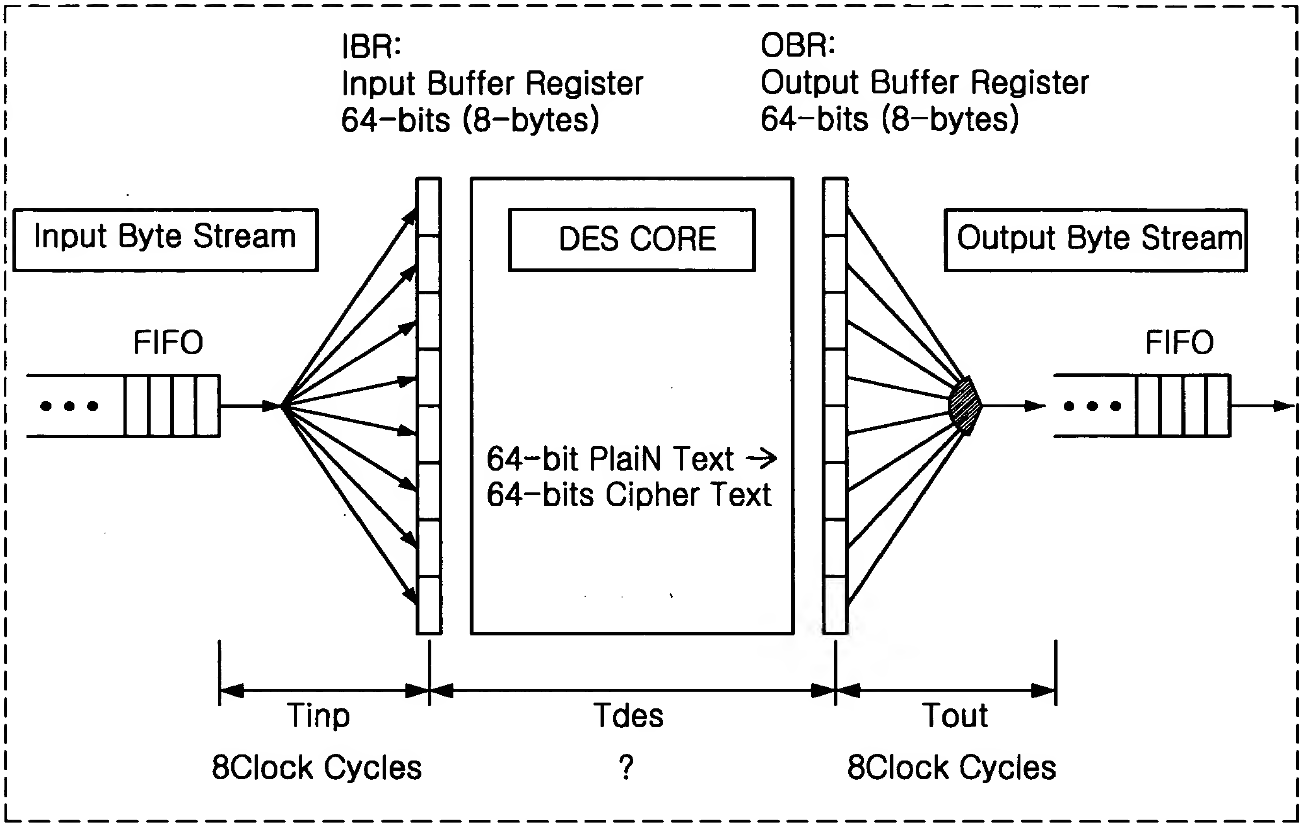
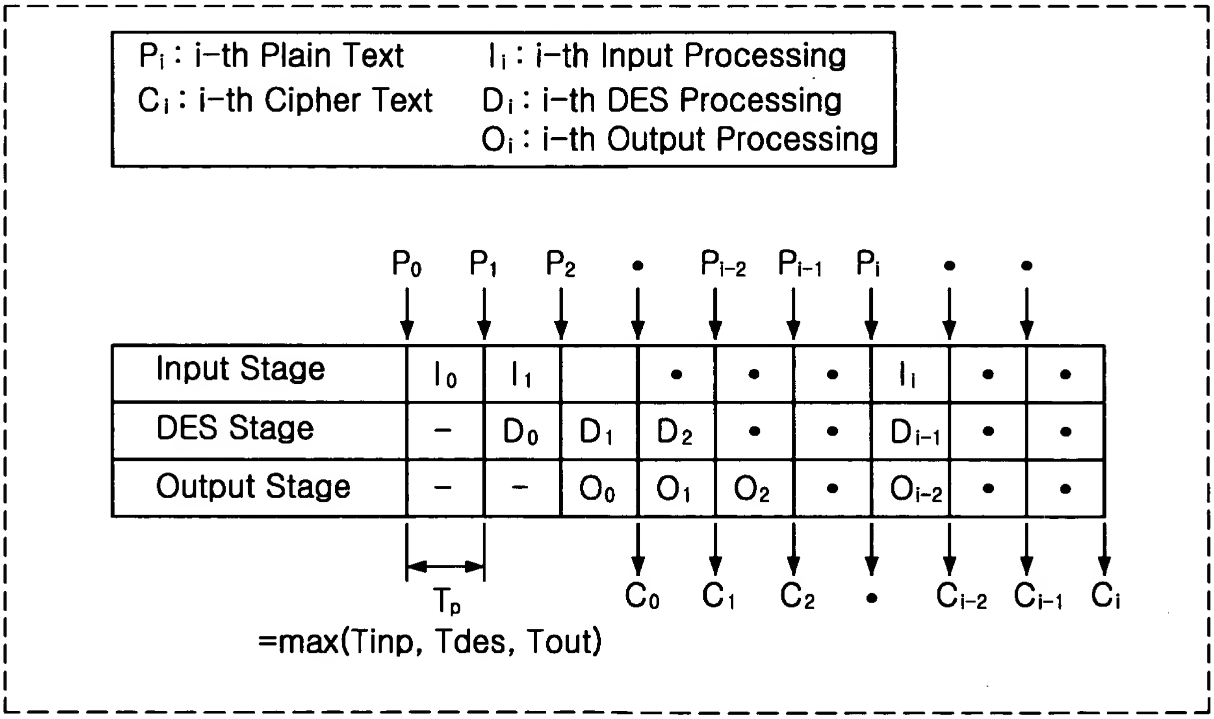


FIG. 4
(PRIOR ART)





P_i : i-th Plain Text
C_i : i-th Cipher Text
I_i : i-th Input Processing
D_i : i-th DES Processing
O_i : i-th Output Processing

	P_0	P_1	P_2	•	P_{i-2}	P_{i-1}	P_i	•	•
Input Stage	I_0	I_1		•	•	•	I_i	•	•
DES Stage	–	D_0	D_1	D_2	•	•	D_{i-1}	•	•
Output Stage	–	–	O_0	O_1	O_2	•	O_{i-2}	•	•

FIG. 5A
(PRIOR ART)

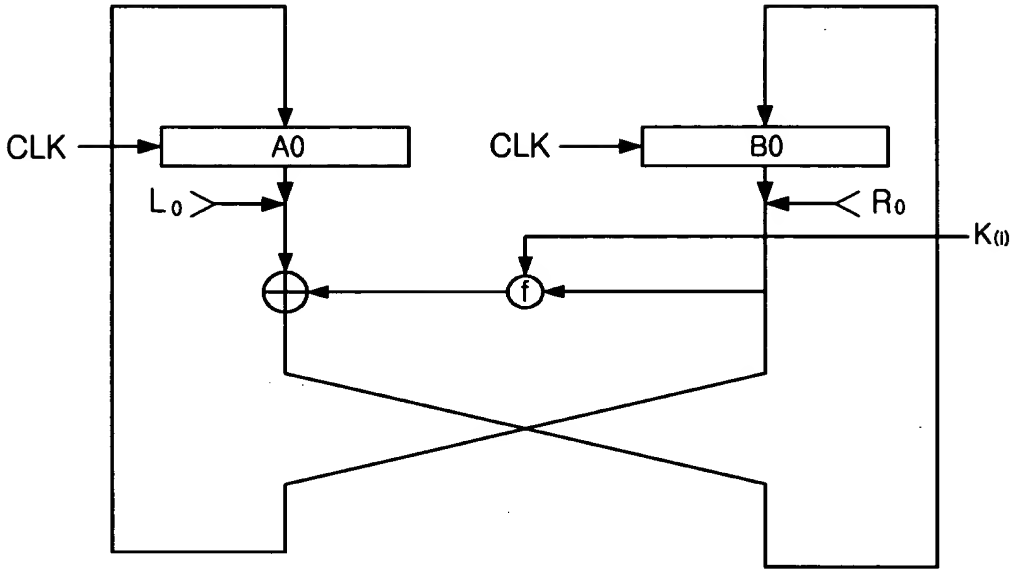


FIG. 5B

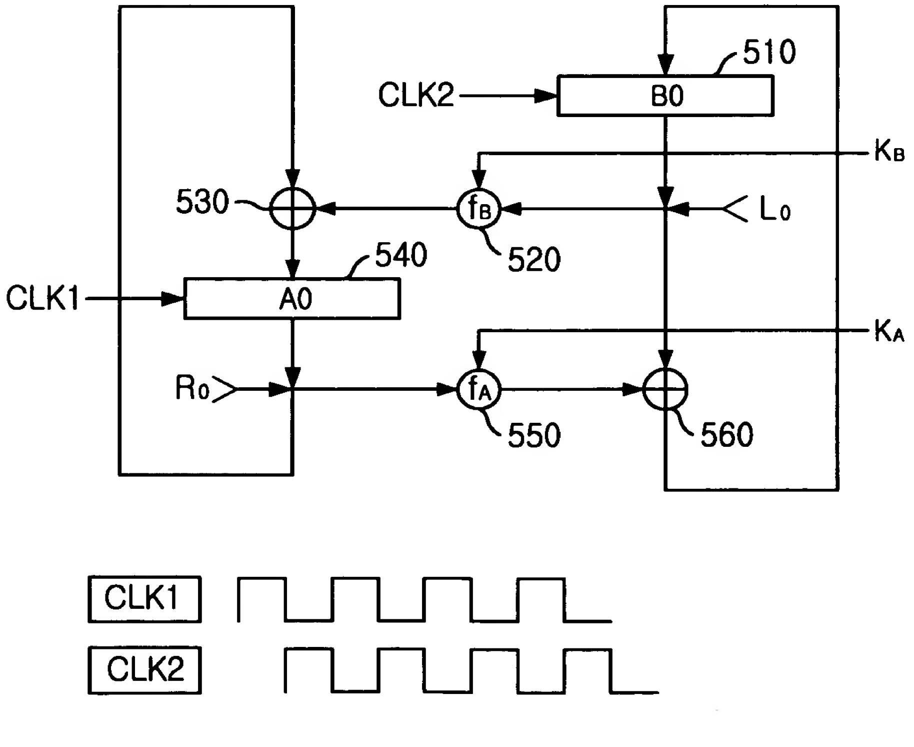


FIG. 6

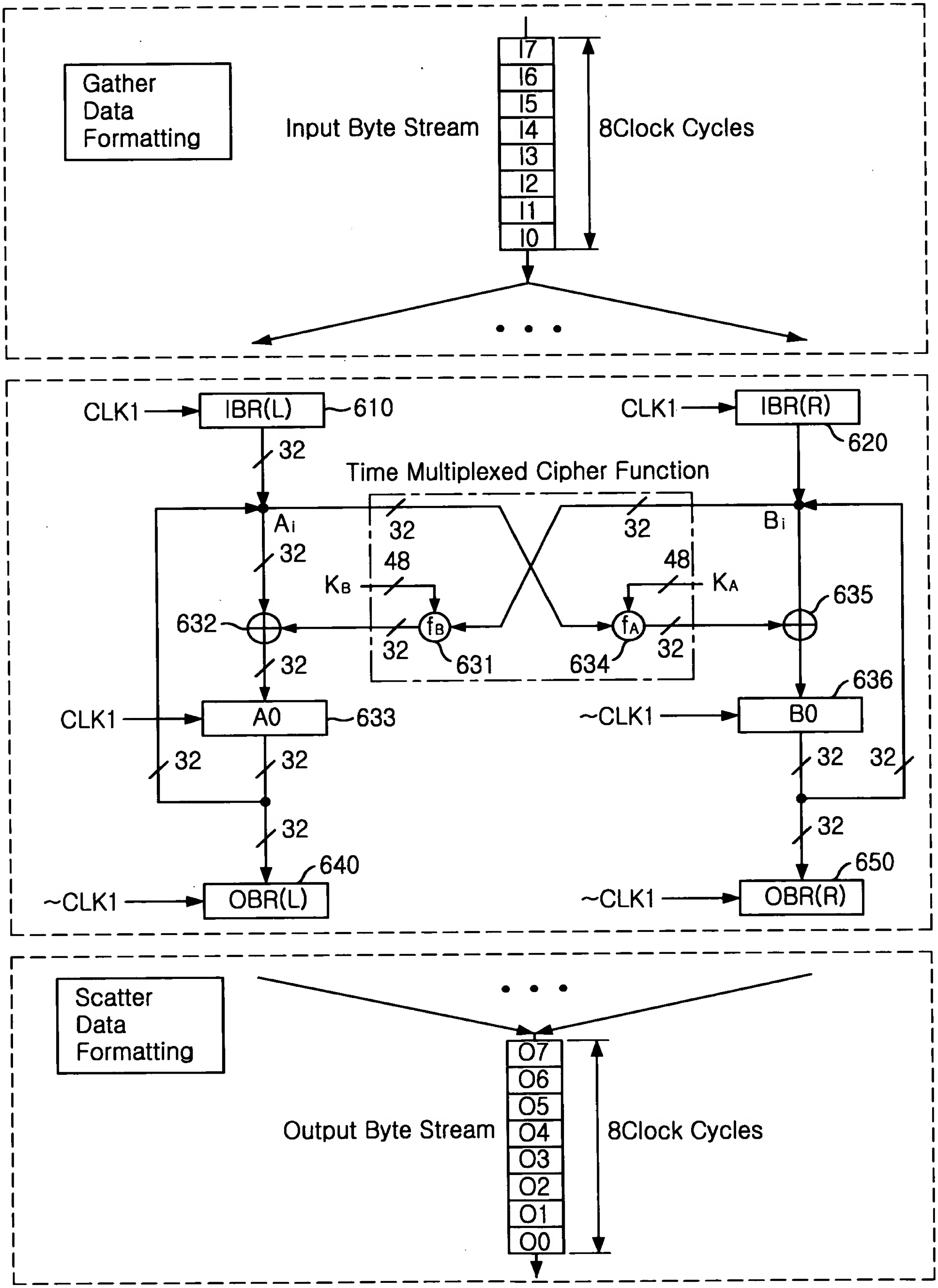
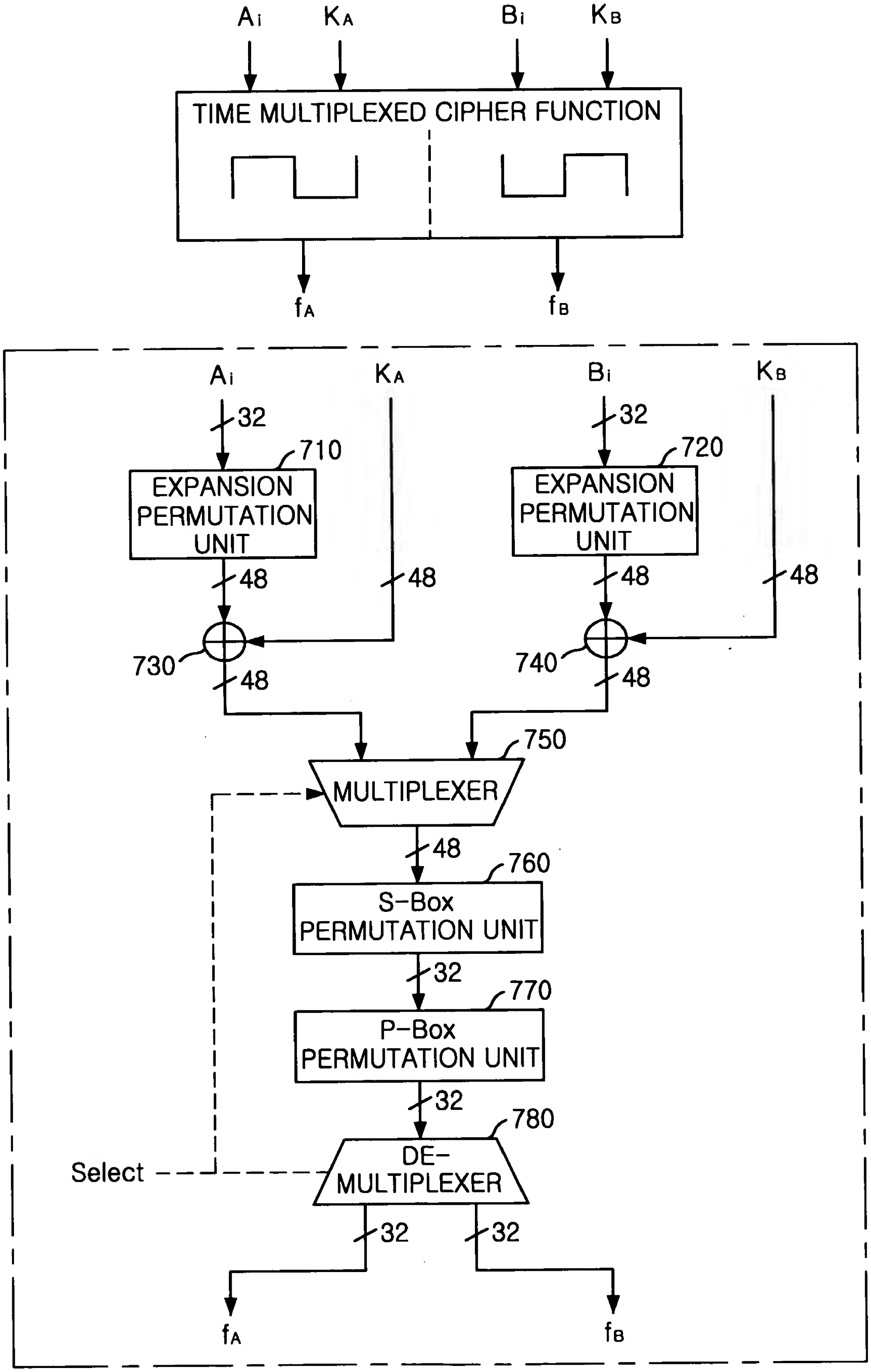

Gather
Data
Formatting
Input Byte Stream
I7
I6
I5
I4
I3
I2
I1
I0
8Clock Cycles
CLK1
IBR(L)
610
32
CLK1
IBR(R)
620
Time Multiplexed Cipher Function
Ai
32
32
32
Bi
48
48
KB
KA
635
632
fB
fA
32
32
631
634
32
636
CLK1
A0
633
~CLK1
B0
32
32
32
32
32
32
640
650
~CLK1
OBR(L)
~CLK1
OBR(R)
Scatter
Data
Formatting
Output Byte Stream
O7
O6
O5
O4
O3
O2
O1
O0
8Clock Cycles

FIG. 7



Ai
KA
Bi
KB
TIME MULTIPLEXED CIPHER FUNCTION
fA
fB
Ai
KA
Bi
KB
32
32
710
720
EXPANSION PERMUTATION UNIT
EXPANSION PERMUTATION UNIT
48
48
48
48
730
740
48
48
750
MULTIPLEXER
48
760
S-Box PERMUTATION UNIT
32
770
P-Box PERMUTATION UNIT
32
780
DE-MULTIPLEXER
Select
32
32
fA
fB

FIG. 8

Round	Left Shift Amount	Total Shift Amount
1(P_0)	3	1
2(P_1)	4	4
3(P_2)	4	8
4(P_3)	3	12
5(P_4)	4	15
6(P_5)	4	19
7(P_6)	4	23
8(P_7)	2	27

WHEN KEY IS LOADED FIRST TIME, IT SHOULD BE 1

Round	Left Shift Amount	Total Shift Amount
1(Q_0)	4	2
2(Q_1)	4	6
3(Q_2)	4	10
4(Q_3)	3	14
5(Q_4)	4	17
6(Q_5)	4	21
7(Q_6)	3	25
8(Q_7)	2	0

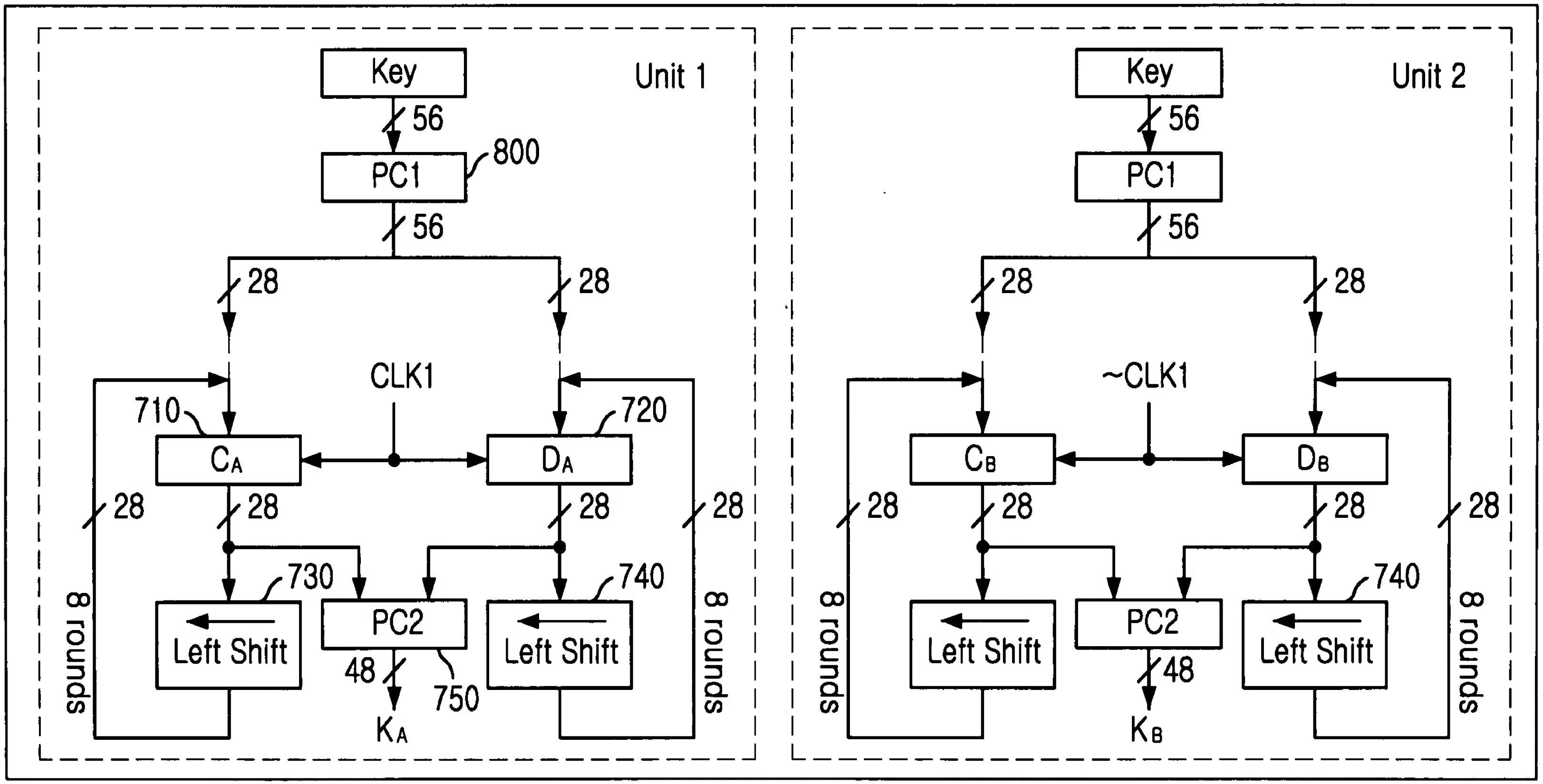


FIG. 9

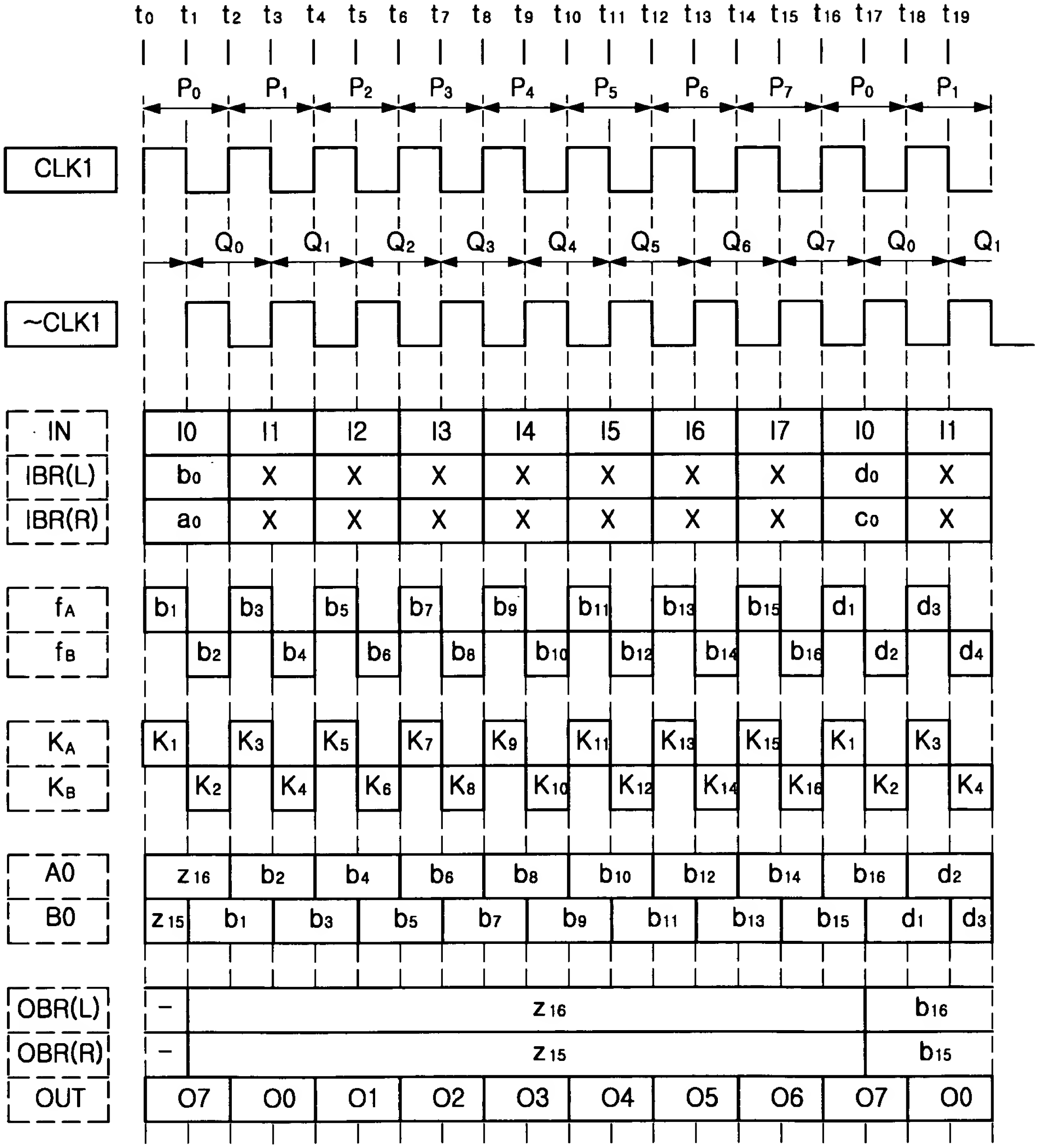
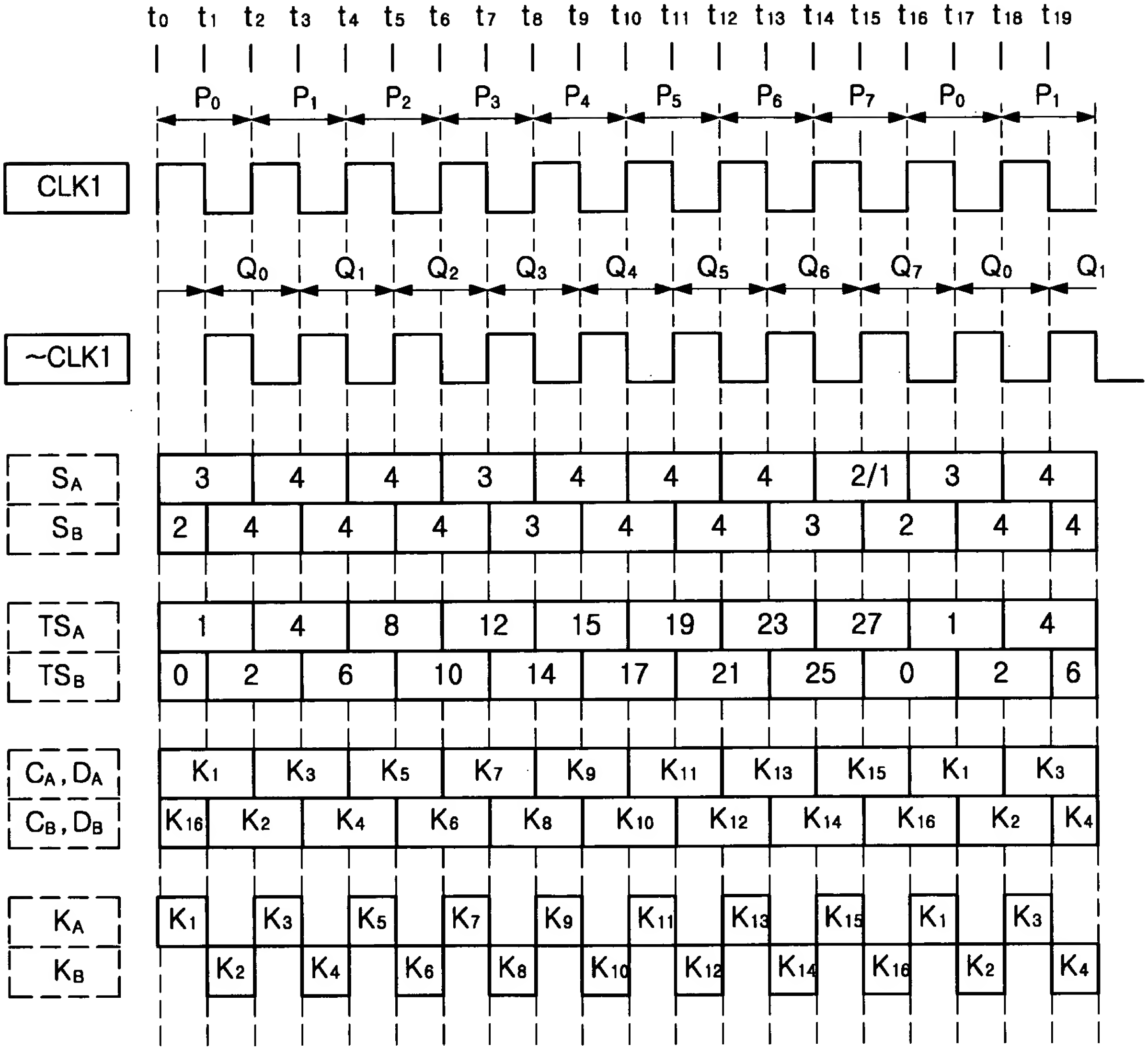

t0 t1 t2 t3 t4 t5 t6 t7 t8 t9 t10 t11 t12 t13 t14 t15 t16 t17 t18 t19
P0 P1 P2 P3 P4 P5 P6 P7 P0 P1
CLK1
Q0 Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q0 Q1
~CLK1
IN
I0 I1 I2 I3 I4 I5 I6 I7 I0 I1
IBR(L)
b0 X X X X X X X d0 X
IBR(R)
a0 X X X X X X X c0 X
fA
b1 b3 b5 b7 b9 b11 b13 b15 d1 d3
fB
b2 b4 b6 b8 b10 b12 b14 b16 d2 d4
KA
K1 K3 K5 K7 K9 K11 K13 K15 K1 K3
KB
K2 K4 K6 K8 K10 K12 K14 K16 K2 K4
A0
z16 b2 b4 b6 b8 b10 b12 b14 b16 d2
B0
z15 b1 b3 b5 b7 b9 b11 b13 b15 d1 d3
OBR(L)
– z16 b16
OBR(R)
– z15 b15
OUT
O7 O0 O1 O2 O3 O4 O5 O6 O7 O0

FIG. 10



t_0 t_1 t_2 t_3 t_4 t_5 t_6 t_7 t_8 t_9 t_{10} t_{11} t_{12} t_{13} t_{14} t_{15} t_{16} t_{17} t_{18} t_{19}
P_0 P_1 P_2 P_3 P_4 P_5 P_6 P_7 P_0 P_1
CLK1
Q_0 Q_1 Q_2 Q_3 Q_4 Q_5 Q_6 Q_7 Q_0 Q_1
~CLK1
S_A
3 4 4 3 4 4 4 2/1 3 4
S_B
2 4 4 4 3 4 4 3 2 4 4
TS_A
1 4 8 12 15 19 23 27 1 4
TS_B
0 2 6 10 14 17 21 25 0 2 6
C_A, D_A
K_1 K_3 K_5 K_7 K_9 K_{11} K_{13} K_{15} K_1 K_3
C_B, D_B
K_{16} K_2 K_4 K_6 K_8 K_{10} K_{12} K_{14} K_{16} K_2 K_4
K_A
K_1 K_3 K_5 K_7 K_9 K_{11} K_{13} K_{15} K_1 K_3
K_B
K_2 K_4 K_6 K_8 K_{10} K_{12} K_{14} K_{16} K_2 K_4

FIG. 11

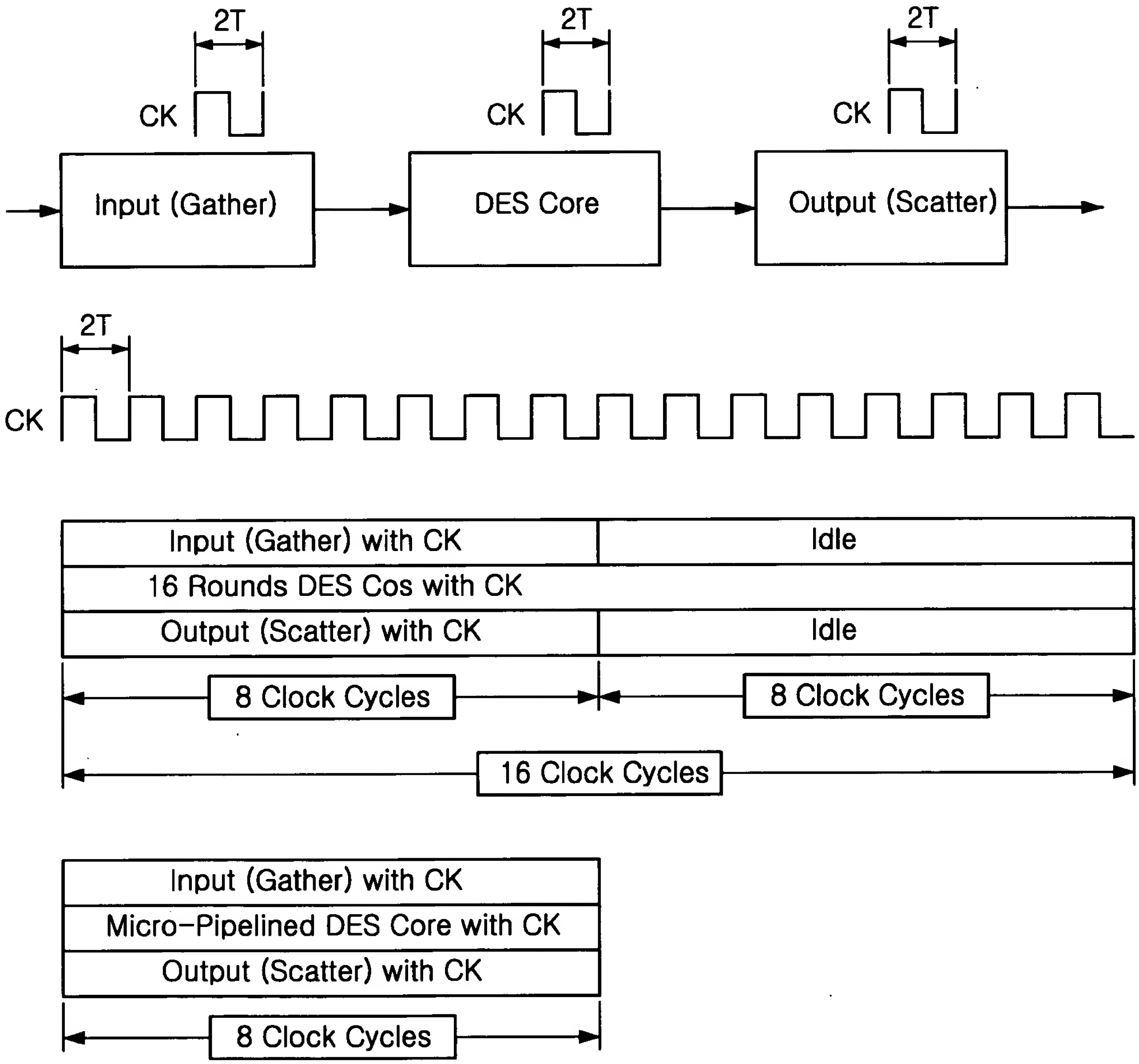
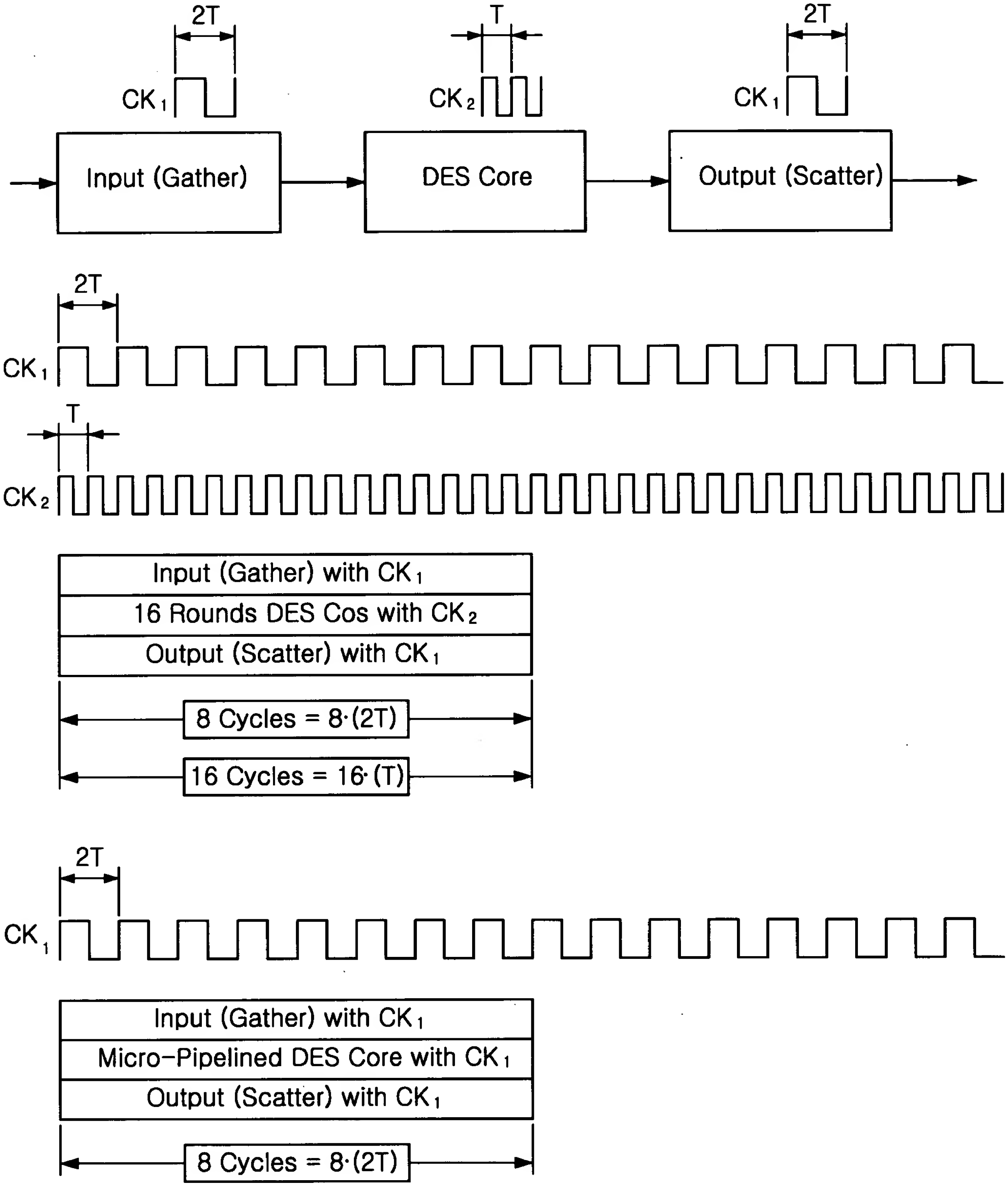

2T
CK
Input (Gather)
2T
CK
DES Core
2T
CK
Output (Scatter)
2T
CK
Input (Gather) with CK
Idle
16 Rounds DES Cos with CK
Output (Scatter) with CK
Idle
8 Clock Cycles
8 Clock Cycles
16 Clock Cycles
Input (Gather) with CK
Micro-Pipelined DES Core with CK
Output (Scatter) with CK
8 Clock Cycles

FIG. 12


2T
CK$_1$
T
CK$_2$
2T
CK$_1$
Input (Gather)
DES Core
Output (Scatter)
2T
CK$_1$
T
CK$_2$
Input (Gather) with CK$_1$
16 Rounds DES Cos with CK$_2$
Output (Scatter) with CK$_1$
8 Cycles = 8·(2T)
16 Cycles = 16·(T)
2T
CK$_1$
Input (Gather) with CK$_1$
Micro-Pipelined DES Core with CK$_1$
Output (Scatter) with CK$_1$
8 Cycles = 8·(2T)